

Open Source Release of EUROPA 2

At NASA ARC, research over the last decade has focused on autonomous systems onboard spacecraft that would enable them to intelligently adapt to the environment while carrying out the goals of their human controllers on earth. Such plans have to be robust to failure as well be opportunistic to science and engineering needs arising time to time. The effort has resulted in enabling spacecraft in inter-planetary space and Mars rovers to efficiently undertake their activities while minimally supervised by human controllers on earth. A key part of the software that has enabled such advances has been the use and deployment of the EUROPA planner.

EUROPA (Extendable Uniform Remote Operations Planning Architecture) is an advance constrained based temporal planning software which at its core has a rich representation to reason about robotic actions in the real-world. Its action based schema reasons about time and resources using a flexible temporal representation allowing for plans generated either onboard or on earth to be robustly executed in the face of uncertain outcomes. EUROPA derives its legacy from the HSTS planner flown on NASA's New Millennium Deep Space One mission in 1999 as part of the RAX (Remote Agent Experiment). RAX demonstrated that planning techniques could enable mission planning in-situ while being responsive to (injected) failures in spacecraft state with limited human control from earth. For the advances in command and control and the novelty of RAX, it won NASA's coveted 1999 Software of the Year Award.

A subsequent version of HSTS was renamed EUROPA and then deployed on the ground at Jet Propulsion Laboratory as part of the MAPGEN (Mixed-initiative Activity Plan GENerator) project on the Mars Exploration Rovers (MER) mission. MAPGEN uses human-computer interactions to determine the best strategy to make optimal use of onboard resources given engineering constraints to keep the two rovers healthy and to enable as many scientific observations as possible while enforcing scientists' constraints. MAPGEN continues to be used in the mission-critical uplink process for the two rovers, Spirit and Opportunity.

A newly reengineered version of the EUROPA planner (EUROPA 2) is now being base-lined for use on 1) the ground for the 2007 Phoenix Mars Lander mission, 2) the 2009 Mars Science Laboratory rover mission as well as 3) for power systems management at the NASA's Johnson Space Center for the International Space Station. EUROPA was also used for plan execution on a Mars analog mission in the Chilean desert on board Carnegie Mellon University's NOMAD robot as part of the Life in the Atacama field campaign.

A novel use of EUROPA is also being undertaken outside NASA at the non-profit Monterey Bay Aquarium Research Institute (MBARI) via a NASA Software Usage Agreement (SUA). EUROPA is part of the Teleo-Reactive Executive (T-REX) which is deployed onboard a MBARI Autonomous Underwater Vehicle (AUV) for adaptively detecting, tracking and sampling water-column properties. EUROPA is being used both to *deliberate* as well as to *act* in the hazardous underwater domain. In a recent at-sea deployment, T-REX demonstrated a mission scenario for a science based volume survey; data obtained by the AUV was demonstrated to be consistent with the nearby MBARI M0 mooring allowing for T-REX data to be verified. Sea trials of T-REX are planned to further enhance MBARI's scientific capabilities and to share this data publicly.